

included in cellular configurations was dispositive in this case. However, the Commission' apparent dismissal of PageNet's application as innovative because of its incorporation and reliance on frequency reuse concepts is inconsistent with its award to MTel of a pioneer's preference for utilization of multicarrier modulation techniques or "MCM."

MCM technology, like frequency reuse, has been in existence for decades. MCM is merely a means of reducing the extent to which multipath signals cause intersymbol interference (ISI) and therefore reducing the production of bit errors in a mobile environment.⁵¹ See Resume and Comments of Dr. Bernhard Keiser, attached hereto as Exhibit A.

Used in landline telephone since approximately World War II, the application of MCM technology to combat multipath interference in a mobile environment goes back at least to the Collin Kineplex system, whose technology was reported in 1957. More recently, MCM was applied in a Rayleigh faded digital mobile communications environment to obtain a 6 dB improvement in signal to interference ratio, the theoretical results of which were confirmed by simulation and also in

⁵¹ Under static conditions, no inherent improvements in spectral efficiencies are gained through MCM.

market applications. MCM's development in both the landline and mobile environment is traced in Exhibit A.⁵²

Given the finding that MTel's MCM application is innovative, even though MTel did not invent MCM and is not the first to apply it in a mobile environment, the Commission cannot dismiss PageNet's application as not innovative because of its reliance on frequency reuse. Either both MTel's and PageNet's proposals are innovative under a standard which rewards the beneficial application of existing technologies to new services, or neither is innovative.

B. PageNet's Bit Rates Far Exceed Those Proposed by MTel

The Commission granted MTel a pioneer's preference for its use of MCM and achieving data rates of 24 kilobits per second in a single 50 kHz channel.⁵³ PageNet, however, has achieved data rates far in excess of those achieved by MTel. PageNet does not herein contest MTel's grant of a pioneer's preference, but, in the face of MTel's grant, the Commission's failure to grant PageNet's application when

⁵² Exhibit A was prepared by Dr. Bernhard Keiser, an internationally known expert in the field of mobile telecommunications, including MCM.

⁵³ See NPRM and Tentative Decision, 7 FCC Rcd at 5735, ¶ 149. As explained above, MTel's reliance on MCM equates to PageNet's reliance on frequency reuse.

PageNet has achieved data rates far in excess of MTel's is arbitrary and capricious.⁵⁴

As noted above, MTel proposes a data rate of 24,000 bits per second in a 50 kHz channel. PageNet, on the other hand, proposes a data rate of 80,000 bits per second in a 25 kHz channel.⁵⁵ Thus, PageNet's transmission speed far exceeds that of MTel. Given that the Commission has implicitly deemed the speed MTel has achieved the yardstick by which increases in transmission speeds will be measured and rewarded, the Commission must also award a preference to PageNet and, perhaps, others who meet or exceed this speed of transmission.

PageNet's transmission speed also compares favorably to MTel's in terms of percentage improvement over state-of-the-art technology. In the first instance, the Commission's conclusion that MTel achieved a "bit rate ten times that of existing simulcast paging systems" is misplaced. A more appropriate comparison to measure improvement is to the ARDIS system, which achieves a data rate of 19,200 bits/second. MTel has clearly proposed to increase the state-of-the-art data rates, but by a far more modest amount than the Commission realizes.

⁵⁴ See generally Greater Boston Television Corp. v. FCC, 444 F.2d 841 (D.C. Cir. 1970), cert. denied, 403 U.S. 923; Johnston Broadcasting Co. v. FCC, 175 F.2d 351, 357 (D.C. Cir. 1949).

⁵⁵ Preference Request at 18.

PageNet's proposed increases in data rates far exceed MTel's. If one compares the data rates PageNet has achieved to ARDIS rates, PageNet's percentage improvement is over 400%. That PageNet's system design achieves greater efficiencies than MTel's is further demonstrated by a comparison of efficiencies for a given unit of bandwidth. MTel's throughput of 24,000 bits/second through 50 kHz represents an efficiency of 0.48 bits per second per Hertz. Digital cellular services achieve an efficiency of 0.795 bits per second per Hertz. PageNet's VoiceNow achieves an efficiency of 3.2 bits per second per Hertz (80,000 ÷ 25) though the modulation techniques it has deployed, thus clearly outperforming either. See Spectral Efficiency Comparison, attached hereto as Exhibit B.

That PageNet's system design offers greater efficiencies than MTel's is also apparent if one calculates spectral efficiency as bits per second per Hertz per square mile. MTel's reliance on simulcast signalling results in no spectral efficiency over a geographic area. PageNet, which deployed frequency reuse to maximize spectral efficiency over a geographic area, of course, achieves far greater spectral efficiency.

In addition, the Commission has apparently glossed over the fact that MTel's technology offers little net benefit to the end user. Although MTel proposes a 24 kbps data transmission rate, it does not provide the end user with any increase in speed, but rather, because of its average three

minute delay, results in a substantial decrease in speed as compared to existing technologies. For example, a 300 character (2400 bit) message transmitted in real time at 2,400 bps would take one second. The same message transmitted on MTel's system, absent the three minute delay, would take 0.1 second. From the user's perspective, however, given the delay, the 2,400 bits are transmitted in three minutes and 0.1 second -- not an increase in speed.

C. VoiceNow Will Result in Increased Spectrum Efficiency and Reduced Cost

The Commission has also stated that it will reward a pioneer's preference for proposals that result in increased spectrum efficiency and reduced cost to the public. MTel made no clear demonstration on the record of how its proposal would satisfy these criteria, nor did the Commission attempt any such evaluation in its Tentative Decision. Conversely, PageNet has provided abundant evidence on the record of how VoiceNow satisfies these criteria. Through PageNet's innovative marriage of simulcast and frequency reuse and spectrum management techniques, coupled with its knowledge and experience in receive system engineering, the potential capacity to serve voice paging users will increase by 2200 percent. PageNet proposed throughput is over 22 times that of existing analog services, representing a 22 time increase in efficiency.

This increased efficiency translates into decreased prices. As subscribers demand more information, they consume more capacity of any given channel. Where fewer subscribers are served, the costs of supporting the system infrastructure has to be borne by a smaller universe of subscribers. By increasing capacity and transmission speeds, PageNet will be able to serve more voice message users on a single channel, driving the price of service down. In fact, PageNet proposes that it will be able to offer VoiceNow services for \$15 to \$20 per month, including pager rental.

V. THE COMMISSION CAN ENSURE THE RAPID DEVELOPMENT OF ADDITIONAL INNOVATIVE VOICE AND DATA NARROWBAND PAGING SERVICES ONLY THROUGH THE AWARD OF ADDITIONAL PIONEER'S PREFERENCES

Among the pioneer's preference requests in this Docket were new, well-developed service proposals rich in detail and of obvious benefit to the public. To further its goals of service diversity and to reward those who developed these services, the Commission should take actions which ensure that at least some of these services are authorized quickly rather than bogged down in a lengthy regulatory debate or drowned in a flood of speculative applications.

Given the 3 MHz of spectrum which the Commission proposes to allocate to advanced messaging services it could, in fact, award all of the applicants for a pioneer's

preference the spectrum they requested, still having two-thirds of the spectrum left for whatever licensing procedures the Commission ultimately adopts. To put this in perspective, the thirteen pioneer's preference applicants collectively would use less than 1/30 the amount of spectrum awarded a single cellular licensee.

CONCLUSION

The Commission must carefully weigh its options in establishing a regulatory scheme which will allow for the future growth and deployment of advanced paging services throughout the country. Specifically, the Commission should take actions that will satisfy market demand. The proposals set forth by PageNet with respect to the channelization, geographic scope and grant of licenses, as well as other suggestions contained in PageNet's Comments, will further the development of advanced paging services in response to market

demand. Moreover, PageNet should be granted a pioneer's preference for its innovative VoiceNow service.

Respectfully submitted,

PAGING NETWORK, INC.

By: Judith St. Ledger-Roty
Judith St. Ledger-Roty
Robert J. Aamoth
Kathleen A. Kirby

REED SMITH SHAW & McCLAY
1200 18th Street, N.W.
Washington, D.C. 20036

(202) 457-8656

Its Attorneys

Dated: November 9, 1992

EXHIBIT A

Resume and Comments of Dr. Bernhard Keiser

BERNHARD E. KEISER, D.Sc. E.E.

Bernhard E. Keiser is a consulting engineer in telecommunications and related fields.

Prior to establishing his consulting practice in February, 1975, he was Director, Systems Analysis, ATS-6 Satellite Program, Fairchild Space and Electronics Company, Germantown, MD. He also held the positions of Director, Advanced Engineering, Atlantic Research Corp.; Vice President and Technical Director, Page Communications Engineers; and Engineering Manager, RCA.

Dr. Keiser is the author of the book, *Broadband Coding, Modulation and Transmission Engineering*, and co-author of the book, *Digital Telephony and Network Integration*. He is a Fellow of the IEEE, The Washington Academy of Sciences and the Radio Club of America. He is listed in *Who's Who in America*, *Who's Who in Engineering*, and *American Men of Science*.

Dr. Keiser has served as Chairman of the Northern Virginia Section of the IEEE. He holds the D.Sc. degree in Electrical Engineering from Washington University, St. Louis, MO.

BERNHARD E. KEISER, DScEE

Experience in digital cellular telephony and related technologies:

- * Developed the RF and speech coding portions of the Request for Proposal issued by BellSouth Mobility, Inc., Atlanta, GA, for a digital cellular system for Georgia.
- * Served as consulting engineer to IMM, Inc., Philadelphia, PA, in the development of Ultraphone, a digital telephone system for BETRS use in rural areas.
- * Teaches course in Digital Cellular Telephony (US standards) for The George Washington University, Washington, DC.
- * Teaches course in Digital Cellular Telephony (GSM standard) for Frost & Sullivan, Ltd., London, UK.
- * Co-author of text *Digital Telephony and Network Integration*, VanNostrand, 1985. (Now under revision to include a full chapter on digital cellular telephony.)

COMMENTS ON FCC "AMENDMENT OF THE COMMISSION'S RULES TO ESTABLISH NEW COMMUNICATIONS SERVICES" (JULY 16, 1992)

Prepared by Bernhard E. Keiser, D.Sc. E.E.

On July 16, 1992, the Federal Communications Commission issued a notice of Proposed Rule Making and Tentative Decision to grant a Pioneer's Preference to Mobile Telecommunication Technologies Corporation (MTel) for new personal communications services in the 930-931 MHz band. This Pioneer's Preference would be based on MTel's proposed use of Multicarrier Modulation (MCM) at 24,000 bits per second in a 50 kHz channel.¹

DATA TRANSMISSION RATE

The increased speed of transmission which MTel proposes, 24,000 bits per second in a 50 kHz channel, is not a spectacular breakthrough in data transmission speed, relative to other state-of-the-art technologies. The

¹ MCM consists of taking a data stream of r bits/second (b/s) and converting it into n streams, each at a rate of r/n b/s. These n streams then are frequency-division multiplexed (FDM) for transmission. Accordingly, MCM does not change the spectral efficiency of a modulation technique. It simply lengthens the symbol durations, thereby reducing the extent to which multipath can cause intersymbol interference (ISI), and ISI's consequent production of bit errors in the mobile environment. As is well known in mobile telecommunications, multipath propagation results in a delay spread of the received signal, with consequent intersymbol interference (ISI). The amount of ISI depends on the symbol duration relative to the delay spread. Making the symbol duration longer reduces the ISI. The symbol duration can be lengthened without reducing the data rate by sending multiple symbols simultaneously. This is what is done in MCM.

American Digital Cellular standard, adopted in 1990 by the Telecommunications Industry Association (TIA) and already in service, transmits data through a 30 kHz channel at 23,850 bits per second.² PageNet's VoiceNow achieves data throughput almost the same as that of digital cellular. The improvements in data transmission rate claimed by MTel are only impressive when compared to the primitive state of some paging systems in the U.S.

SPECTRAL EFFICIENCY

Moreover, the simple data transmission rate is not the best measure of spectral efficiency. The bandwidth utilized and the geographic area covered by a transmission must be considered. MTel's efficiency for a given unit of bandwidth is actually inferior to existing technologies by that measure. MTel's 24,000 bits per second through 50 kHz represents an efficiency of 0.48 bps/Hz. Digital cellular, already in service, achieves an efficiency of 0.795, greater than the efficiency for which MTel has been tentatively granted a pioneer's preference. VoiceNow, utilizing similar modulation techniques, achieves data rates comparable to digital cellular.

² "Proposed new IS-54 Cellular System Dual-Mode Mobile Station - Base Station Compatibility Standard," Telecommunications Industry Association, 1722 Eye Street, Suite 4040, Washington, DC 20006, January 31, 1990.

Also, because the proposed MTel system is simulcast, no efficiency over geographic area is achieved. This is unusual in an era when spectral efficiency is so important. All wireless systems developed in the past decade depend upon frequency reuse to maximize spectral efficiency -- cellular, digital SMR, VoiceNow.

INNOVATION

The Pioneer's Preference, as understood by this writer, is issued for the innovative use of new technology. The FCC has not judged the application of the frequency reuse concept to paging services by PageNet to be innovative; yet, the use of a much older concept, MCM, by MTel somehow appears to be innovative in the eyes of the FCC.

MCM-ORIGIN: MCM technology is based on FDM (frequency division multiplexing). This technology has been in use by the common carriers since before World War II. AT&T developed the use of the group (12 channel) and supergroup (60 channel) transmission of voice on a single sideband (SSB) basis, thereby eliminating the need for an independent wire pair for each voice channel in telephony. This technology was put to further use after World War II as mastergroup (600 channel) transmission was initiated on microwave radio systems.

MCM-1957: The use of MCM to combat multipath goes back at least to the Collins Kineplex system, whose technology was reported in 1957.³

MCM-1966: Chang described a method of using multitone techniques to eliminate ISI and interchannel interference between overlapping channels.⁴ He developed the criteria for the orthogonality of tones in terms of channel synchronization and signal design. He also described the amplitude and phase characteristics for the transmitting filter. His approach has been called vestigial sideband (VSB) since his tones (channels) are orthogonal, but the individual tones themselves are not quadrature modulated.

MCM-1967: Saltzberg described the benefits of half-cosine channel roll-offs in the presence of delay and amplitude distortion.⁵ His application is to band-limited dispersive media, of which the mobile channel is a good example. He uses Chang's criteria, and places the adjacent channels in phase quadrature.

³ M. L. Doelz, E. T. Heald, and D. L. Martin, "Binary Data Transmission Techniques for Linear Systems," *Proc. IRE*, Vol. 45, pp. 656-661, May, 1957.

⁴ R. W. Chang, "Synthesis of Band-Limited Orthogonal Signals for Multichannel Data Transmission," *Bell System Technical Journal*, December 1966, pp. 1775-1796.

⁵ B. R. Saltzberg, "Performance of an Efficient Parallel Data Transmission System," *IEEE Transactions on Communications Technology*, Vol. COM-15, No. 6, pp. 805-811, December 1967.

MCM-1971: Weinstein and Ebert described the use of FDM with overlapping subchannels to avoid equalization, combat impulsive noise, and use bandwidth efficiently.⁶

MCM-1980: Hirosaki described the use of automatic equalization to eliminate both ISI and crosstalk in an OQAM system.⁷ The term orthogonal is used here in the sense that each signal frequency involves orthogonal (i.e., a sine wave and a cosine wave) modulation.

MCM-1981: Hirosaki introduced digital signal processing (DSP) to MCM to reduce the complexity and cost of an OQAM system, and made use of finite impulse response (FIR) filters.⁸

MCM-1985: Cimini applied orthogonal FDM to the Rayleigh faded digital mobile channel for a 6 dB improvement in signal to interference ratio (S/I) over the bursty Rayleigh channel with respect to the effects of flat Rayleigh fading.⁹ Cimini also points out that RDM (the "parallel

⁶ S. B. Weinstein and P. M. Ebert, "Data Transmission by Frequency-Division Multiplexing Using the Discrete Fourier Transform," *IEEE Transactions on Communications Technology*, Vol. COM-19, No. 5, pp. 628-634, October, 1971.

⁷ B. Hirosaki, "An Analysis of Automatic Equalizers for Orthogonally Multiplexed QAM Systems," *IEEE Transactions on Communications*, Vol. COM-28, No. 1, pp. 73-83, January, 1980.

⁸ B. Hirosaki, "An Orthogonally Multiplexed QAM System Using the Discrete Fourier Transform," *IEEE Transactions on Communications*, Vol. COM-29, No. 7, pp. 982-989, July, 1981.

⁹ L. J. Cimini, "Analysis and Simulation of a Digital
Continued on following page

approach," as he calls it) spreads out a fade over many symbols, effectively randomizing the burst errors caused by the Rayleigh fading, so that instead of several adjacent symbols being completely destroyed, many symbols are only slightly distorted. This allows the precise reconstruction of a majority of the symbols.

Cimini verified his results by simulation, but points to numerous hardware implementations in his paper, including such military systems as KINIPLEX, ANDEFT, and KATHRYN, as well as several voice band data modem applications.

MCM-1986: Hirosaki et al. described a data modem using OQAM, noting the superior performance of OQAM over VSB by 4 dB.¹⁰ The improvement results not only from the 3 dB improvement noted previously, but also from the absence of carrier tones in the OQAM modem. He also points to advantages of the technique with respect to Gaussian noise, impulse noise, and channel distortions.

MCM-1987: Ruiz and Cioffi applied trellis coding to a coder using frequency bins.¹¹ In this approach, the

Continued from previous page

Mobile Channel Using Orthogonal Frequency Division Multiplexing," *IEEE Transactions on Communications*, Vol. COM-33, No. 7, pp. 665-675, July, 1985.

¹⁰ B. Hirosaki, S. Hasegawa, and A. Sabato, "Advanced Groupband Data Modem Using Orthogonally Multiplexed QAM Technique," *IEEE Transactions on Communications*, Vol. COM-34, No. 6, pp. 587-592, June, 1986.

¹¹ A. Ruiz and J. M. Cioffi, "A Frequency Domain Approach
Continued on following page

allocation of energy versus frequency within the overall channel is determined by the channel's characteristics. In other words, the amplitude at which each frequency bin is transmitted is determined by the channel's characteristics at the moment.

MCM-1989: Kalet evaluated multitone QAM, showing its benefits in channels with deep nulls.¹² His results are similar to those of Ruiz and Cioffi.

MCM-1990: Bingham described the advantages of MCM based on the use of QAM rather than OOK (VSB), as advocated by MTel.¹³ Bingham discusses the use of trellis coding (a judicious combination of coding and modulation) in an MCM system.

MCM-1991: Casas and Leung treated a set of orthogonal FDM (OFDM) channels as a baseband and frequency modulated them onto a single carrier to simplify the receiver and to reduce costs.¹⁴ The results are analyzed, and are as

Continued from previous page
to Combined Spectral Shaping and Coding," *IEEE International Conference on Communications - 1987*, Paper 49.3, pp. 1711-1715, 1987.

12 I. Kalet, "The Multitone Channel," *IEEE Transactions on Communications*, Vol. 37, No. 2, pp. 119-124, February, 1989.

13 J. A. C. Bingham, "Multicarrier Modulation for Data Transmission; An Idea Whose Time Has Come," *IEEE Communications Magazine*, May, 1990, pp. 5-14.

14 E. F. Casas and C. Leung, "OFDM for Data Communication Over Mobile Radio FM Channels -- Part I: Analysis and Experimental Results," *IEEE Transactions on Communications*, Vol. 40, No. 4, pp. 680-683, April, 1992.

expected. In 1992, the same authors described the use of switching diversity, forward error correction (FEC), automatic gain control (AGC), and squelch for improving OFDM performance.¹⁵

¹⁵ "Proposed new IS-54 Cellular System Dual-Mode Mobile Station - Base Station Compatibility Standard," Telecommunications Industry Association, 1722 Eye Street, Suite 4040, Washington, DC 20006, January 31, 1990.

EXHIBIT B

Spectral Efficiency Comparison

SPECTRAL EFFICIENCY COMPARISON

Spectral Efficiency Improvement Over Current State-of-the-Art

	<u>Data rate</u> <u>(kb/sec)</u>	<u>Bandwidth</u> <u>(kHz)</u>	<u>Efficiency</u> <u>bits/sec/Hz</u>	<u>Average</u> <u>Message</u> <u>Length</u> <u>(sec.)</u>	<u>Improvement</u>
VoiceNowSM					
Analog voice		25		15	
PageNet VoiceNow SM	80	25	3.2	1.5	1000%*

*As a result of frequency reuse and other spectrum conservation measures, total system improvement is 22 times that of analog voice paging system.

One-Way Data

ERMES	6.25	25	0.25	
GEM	6.25	25	0.25	0%*
Metriplex	2.4	25	0.10	-62%
MobileComm	15	50	0.30	+20%
PacTel AAP	?	25-50	?	none demonstrated
PacTel GAP	?	25	?	none demonstrated

*30% claimed as a result of "proprietary" technology.

2-Way Mobile Data

ARDIS	19.2	25	0.77	
Freeman	?	150	?	none demonstrated
Mtel	24	50	0.48	-38%

CERTIFICATE OF SERVICE

I, Laverne Watkins, hereby certify that copies of the foregoing COMMENTS OF PAGING NETWORK, INC. were hand-delivered this 9th day of November 1992 to the following:

Honorable Alfred C. Sikes
Chairman
Federal Communications Commission
1919 M Street, N.W., Room 814
Washington, D.C. 20554

Honorable James H. Quello
Commissioner
Federal Communications Commission
1919 M Street, N.W., Room 802
Washington, D.C. 20554

Honorable Sherrie P. Marshall
Commissioner
Federal Communications Commission
1919 M Street, N.W., Room 826
Washington, D.C. 20554

Honorable Andrew C. Barrett
Commissioner
Federal Communications Commission
1919 M Street, N.W., Room 844
Washington, D.C. 20554

Honorable Ervin S. Duggan
Commissioner
Federal Communications Commission
1919 M Street, N.W., Room 832
Washington, D.C. 20554

John Cimko, Jr., Chief
Mobile Services Division
Common Carrier Bureau
Federal Communications Commission
1919 M Street, N.W., Room 644
Washington, D.C. 20554

Myron C. Peck, Deputy Chief
Mobile Services Division
Common Carrier Bureau
Federal Communications Commission
1919 M Street, N.W., Room 644
Washington, D.C. 20554

Ralph A. Haller, Chief
Private Radio Bureau
Federal Communications Commission
2025 M Street, N.W., Room 5002
Washington, D.C. 20554

Gerald P. Vaughan, Deputy Bureau Chief
Common Carrier Bureau
Federal Communications Commission
1919 M Street, N.W., Room 500
Washington, D.C. 20554

Richard J. Shiben, Chief
Private Radio Bureau
Land Mobile and Microwave Division
Federal Communications Commission
2025 M Street, N.W., Room 5202
Washington, D.C. 20554

Rosalind K. Allen, Chief
Private Radio Bureau
Rules Branch
Federal Communications Commission
2025 M Street, N.W., Room 5202
Washington, D.C. 20554

Thomas P. Stanley, Chief Engineer
Office of Engineering and Technology
Federal Communications Commission
2025 M Street, N.W., Room 7002
Washington, D.C. 20554

Bruce A. Franca
Deputy Chief Engineer
Office of Engineering and Technology
Federal Communications Commission
2025 M Street, N.W., Room 7002
Washington, D.C. 20554

David R. Siddall, Chief
Office of Engineering and Technology
Frequency Allocation Branch
Federal Communications Commission
2025 M Street, N.W., Room 7102
Washington, D.C. 20554

Robert M. Pepper, Chief
Office of Plans and Policy
Federal Communications Commission
1919 M Street, N.W., Room 822
Washington, D.C. 20554

James L. Gattuso, Deputy Chief
Office of Plans and Policy
Federal Communications Commission
1919 M Street, N.W., Room 822
Washington, D.C. 20554

Richard E. Wiley
R. Michael Senkowski
David E. Hilliard
Eric W. DeSilva
WILEY, REIN & FIELDING
1776 K Street, N.W.
Washington, D.C. 20006
(Counsel for Mobile Telecommunication
Technologies Corporation)


Laverne Watkins